Method for inducing or promoting an anthocyanin coloration in plants and/or fruit which basically produce anthocyanin.

**Area of the invention:**

The invention relates to a method for inducing or promoting an anthocyanin coloration in plants and/or fruit which basically produce anthocyanin.

**Background of the invention:**

One of the most important goals of fruit production is the longest possible storage of fruit, which still looks attractive, tastes good, and is healthy. For this reason, apples as a fruit are so important at a moderate degree, because most varieties meet this requirement. In order to achieve this goal, storage of apples nowadays is done in so-called ULO storage ("ultra low oxygen"), or CA storage ("controlled atmosphere"), which contain increased carbon monoxide levels, and substantially decreased oxygen levels at a temperature of 0°C. This prevents the metabolism and ripening, and achieves a storage capability of up to 6 months or more. Prior to this method, merely the temperature was regulated, which leads to reduced storage times. To the consumer, the concentration of the red pigmentation (coloration) of the apples' skin is an important criterion for quality. The redness of the apple therefore determines the value of the apple on the market.

It is therefore considered as disadvantageous, that the redness of the fruit in a tree has always varied considerably, and the fruit growing in the shade is therefore labeled as a lower quality fruit, mainly due to its color. Additionally, there are numerous well-known and well-tasting varieties, which hardly turn red, and which are therefore less popular than they could be, such as Cox Orange. With the sales of various varieties experience clearly shows that the red color is the most important of all selection criteria. Important

varieties, which do not turn red, are Golden Delicious (Europe and worldwide), and Granny Smith, which is mostly produced in the Southern Hemisphere (New Zealand).

It is therefore the continuous goal of apple growers to produce, or promote the red color in apples.

Although the mechanism of a pigmentation of the apple's skin cannot yet be explained in detail, it is known that adequate exposure to sunlight, but also artificial light (DE 3409796, WO 86/00492), does increase pigmentation. Additionally, it is known that chemical substances (FR 81 15845, EP 0 598 304) can also favorably influence the pigmentation of apple skin. However, the use of chemical substances is not always without risk (FR 81 15845), or does not show the desired effect in all apple varieties, and the methods using sunlight depend on their availability.

Known methods of artificial lighting generally use white light, or light simulating sunlight, that is, they attempt to supplement or replace natural sunlight.

It is also known from DE 34 09 796 how to promote anthocyanin production in fruit and plants with the use of a combination of blue and red light. The selection for the spectral range selected for this irradiation is based on the fact that two photo-chemical reactions are known for anthocyanin synthesis, namely an energy-weak red/long wave-red, reversible phytochrome controlled reaction, and an intensive irradiation reaction, which is most effective in the blue and in the long wave range of the viewable light spectrum. The phytochrome is discussed, or presumed as a photo receptor in these photo reactions involved in the production of anthocyanin.

WO 86/00492 describes a method for identifying apples, in which the apples are equipped with a lightproof mask and are then irradiated using an artificial light source

for example, a white light emitting fluorescent light source.

Nowadays, market demands require optimally reddened fruit appealing to the eye on one hand, while on the other, the market is especially critical to the use of artificial means, such as the application of chemical substances. Whereas, producing redness with the use of light for producing redness can be achieved without chemicals. However, the previously described methods, such as night interruption treatment before the harvest, are elaborate and have little effect, and the known irradiation methods using white, blue, or red light are tedious and require improvement for this reason alone. So far, a change in color of anthocyanin-colored fruit of plant parts in the sense of an increased attraction of this fruit or these plants could not be achieved.

The presented invention is therefore based on the task of supplying a method for inducing or promoting an anthocyanin coloration in plants and/or fruit, which is characterized by an especially rapid effect, and can be easily integrated into established steps in the planting process all the way up to the sales process, while especially enabling the red coloration of plant (parts) or fruit, which normally do not develop a red color, as for instance, in so-called green apple varieties.

**Abstract**

Surprisingly, it was now detected that UVB light and light, which combines a mixture of white light and light from the spectral range of the UVB, not only promotes the production of anthocyanin in plants and/or fruit, but possibly even induces it. With the use of UVB light in combination with white light, the UVB contents should be higher than in sunlight, while assuming that the UVB part in sunlight (median) is 2.5%. The

anthocyanin coloration according to the invention can be further promoted by irradiation using white light and additionally at least one light source emitting blue light.

**Detailed Description of the Invention**

Principally, the inventive method can be used with all anthocyanin producing structures of plants (for instance blooms and leaves), or their fruit, respectively. Anthocynines cause a yellow, orange, red, and blue-violet as well as blue coloration, consisting of various mixed substances, which are stored in the cell plasmas. Almost all superficial cells (epidermis) of the plants' above-surface organs store anthocyanin especially well, however, they are by far not always variegated, instead they are often filled with colorless, only UV light absorbing anthocyanins. The chemical structure of the yellow, yellowish-red, and red anthocyanins is somewhat simpler than the blue ones. Some plant are unable to produce red and blue, some are unable to produce any blue anthocyanins. Anthocyanins are also the color substances responsible for the coloration of leaves (such as in dragon trees, coleus plants, and many other ornamental plants). Not all yellow/red fruit/blossoms are colored by anthocyanin. For example, red and yellow bell peppers are colored by carotinoide, which is biosynthetically produced in a completely different way.

Preferably, the inventive method for inducing and promoting red or yellow coloration (the production of red or yellow anthocyanins) is most preferably used for promoting the red coloration, especially in fruit.

Important fruit, which turn red or yellow with the aid of anthocyanin, such as apples, pears, peaches, nectarines, plums, cherries (all rose plants), blueberries, and cranberries, fall into the area of the invention. Preferably, the inventive method is used with pears and apples, but especially with apples.

In an especially preferred method of the invention, the production of anthocyanin is promoted in apples, which, if ripened on the tree, show a red coloration, although often

not to the desired extent. This includes *Cox Orange, Elstar, Gloster, Idared, Jonagold,* and *Pilot.*

In an especially preferred method of the invention, the red coloration of the fruit, especially that of apples, is promoted in fruit that usually does not turn red. This is achieved by irradiation with UVB light, or a mixture of UVB light and white light, and has been successfully performed on the following apple varieties: *Golden Delicious, Zitronenapfel, Granny Smith,* and *Mutsu.*

Due to the fact that a stronger anthocyanin production is promoted using UVB light, or a mixture of UVB light and white light, than using a mixture of white and blue light, the first two variations are preferred.

When using UVB light, light sources are utilized, the irradiation flow of which, ranging from 280-315 nm relative to the total irradiation flow of 100-780 nm ($\Phi_{280\text{-}315\ nm}/\Phi_{100\text{-}780\ nm}$; each measured in watts), is preferably not under 10%, or most preferably not under 20%. The currently preferred examples show a value of $\Phi_{280\text{-}315\ nm}/\Phi_{100\text{-}780\ nm}$ with at least 30%, especially with at least 45%. Higher values (i.e. at least 70%, or at least 90%) are even more beneficial in light of the energy yield. However, lamps using such a higher irradiation flow ranging from 280-315 nm, are usually expensive. Therefore, the use of more reasonably priced, commercially available UVB lamps (for instance, TL 40W/12 from the Philipps company), the value of which (approximately 57%) is upwards of 45% for $\Phi_{280\text{-}315\ nm}/\Phi_{100\text{-}780\ nm}$, can be extremely economical.

Preferably, blue light sources, or white light sources are used analogously, the irradiation flow of which is ($\Phi_{400\text{-}510\ nm}/\Phi_{100\text{-}780\ nm}$), or ($\Phi_{400\text{-}780\ nm}/\Phi_{100\text{-}780\ nm}$), respectively, ranging from 400-510 nm, or 400-780 nm, respectively, relative to the total irradiation flow of 100-780 nm with at least 10%, especially with at least 20% to 30%, however most preferred with at least 45%. Due to the fact that blue, or white light,

respectively, with a irradiation flow of at least 70%, especially with at least 90% can be purchased at a relatively low price, working with these types of light sources is even more preferred.

When working with two light sources, the spectrums of which overlap, i.e. with a mixture of white and blue light, the respective irradiation flow may not be zero, and they should show the previously specified values. Alternatively, a light source can be used, if it contains an irradiation flow density appropriately supplemented in the blue range, as opposed to the white light.

In optimizing the procedural conditions for the irradiation, especially the number and type of the light sources used, their capacity, their arrangement, and distance relative to the fruit, the irradiation time, the temperature, and possibly a subsequent storage under cool conditions, all play a role. Generally, the irradiation with light within the wavelength range specified in detail above should be performed at such intensity, and over such a time frame, that the desired effect is achieved. The specialist can determine the parameters suitable for this in experiments, and without great effort – depending on the light sources available, and their geometric arrangement.

Typically, 1-8, preferably 1-4, but especially 2 light sources are used per light type.

The arrangement of the light sources preferably ensures that the plant(s), or the fruit is irradiated at exactly that point, at which the anthocyanin is to be produced. The arrangement of two light sources per light type above the plant(s) (fruit) is especially preferred. Preferably, both the light source and the fruit (plants) to be irradiated are arranged in an enclosure, or in a container (especially one with reflecting surfaces).

The distance between the [illegible] light source(s) and the individual plants (fruit) is preferably up to 300 cm, especially 25 to 100, whereby 60 to 80 cm is preferred. However, smaller or greater distances can be used, if the other procedural parameters (i.e. spectral irradiation flow, and capacity per lamp, irradiation time) are adjusted accordingly. For example, a greater distance between the fruit (plants) and the light source(s) can be compensated by higher capacity of the light source(s), or by a higher irradiation flow of the light source(s).

The capacity of the light source used usually lies within a range of up to 100W (20-100W), preferably 36-60W per light source. Due to heat and irradiation loss within "undesirable" spectral ranges, however, only a fraction of this capacity is usually irradiated within the "desirable" spectral section. For example, the output capacity of the commercially available UVB fluorescent lamp TL 40W/12 manufactured by Phillips lies within a range of 280-315 nm at 5.1W. When selecting a suitable light source, the fact that a higher capacity in otherwise identical procedural parameters does not automatically result in an accelerated anthocyanin production, should also be considered, because this can cause saturation effects. Wattages of 10 to 20 $W/m^2$ have been measured in some examples.

The following light intensity ranges are preferably used in the inventive method, whereby the stated values refer to the light intensity (in $\mu Es^{-1}m^2$) on the plant or the fruit, and on the wavelength range(s) of the respective light type(s).

Blue/white: more than 1; more preferred are more than 2; especially 20-50;
UVB: more than 0.5; more preferred are more than 1.0; especially 10-20;
UVB/white: more than 0.75; more preferred are more than 1.5; especially 15-20;

When mixing blue with white light, the ratio of light intensities (blue/white) is 1:10 to 10:1. In a mixture consisting of UVB and white light, the preferred ratio is 1:20 to 10:1.

An irradiation over a time period of between 6 hrs and several days is preferred, especially preferred is 12 to 72 hrs, more preferred is 12 to 36 hrs, and the most preferred time period is 12 to 24 hrs. With irradiation of fruit, the selection of the irradiation period depends, among other considerations, on whether the fruit was freshly harvested, or already stored. Freshly harvested fruit usually reacts stronger to UVB light, possibly mixed with white light, than fruit that was stored for a longer period of time (for instance, for more than 100 days, especially if stored for more than one year), so that the end value of the red coloration can be achieved within 72 hrs. In fruit that has been stored for a longer period of time, longer irradiation times than 72 hrs may be required to achieve the end value. The suitable irradiation time period can easily be determined by observing the plants (fruit).

Temperature also influences the anthocyanin production. Typically, irradiation takes place ~~in a climate chamber~~ at temperatures from 5 to 25°C, preferably at 14 to 19°C (especially at 15 to 18°C), whereby the irradiation inside a climate chamber is often particularly beneficial. These temperatures influence the appearance and the taste of the apples at a minimum. An irradiation with the inventive method at 17°C has been proven successful (preferably inside of a climate chamber). Adjustment of the moisture content inside of the climate chamber is not necessary, but it can aid in maintaining the apples' "freshness."

The inventive method can also be applied to fruit still on the shrub or tree, for example, as a night interruption treatment. In the case of fruit from a tree, such as apples and pears, it is preferred to first harvest the fruit, due to economical considerations. The fruit can then be irradiated either in their fresh state, or after a freely selectable period of storage.

It is particularly preferred to store the irradiated fruit in a dark place after irradiation of "fresh" fruit. (Whether a fruit is "fresh," or not depends largely on the storage conditions, and on the type of fruit, so that the varying method described herein not only applies to freshly harvested fruit, but preferably also to fruit stored for up to one year, particularly to fruit stored for up to 100 days.) Anthocyanin production can often be observed during this subsequent storage despite of darkness, which makes this variation of the inventive method particularly beneficial. Preferably, the irradiation over a period of 12 to 72 hrs, preferably 12 to 36 hrs, particularly preferred of 12 to 24 hrs is combined with subsequent storage in darkness for at least 2 to 7 days. Subsequent storage exceeding 10 days, however, is also possible without any problems.

The subsequent storage can be done within a temperature range of 0°C to approximately 30-35°C, whereby temperatures of 0-10°C are preferred in consideration of the desired freshness of the fruit. Surprisingly, it was discovered that a freshly harvested apple, which was irradiated for 1 day, and then subsequently stored (for example 1 day irradiation with UVB light, or a mixture of UVB light and white light, then subsequently stored in the refrigerator at 4°C for 7 days), produced a stronger red coloration, than a freshly harvested apple, which was irradiated for 3 days under the same conditions, and which was not subsequently stored. The previously mentioned ULO storage, or CA storage with their typical storage temperatures of 0°C are also suitable for the subsequent storage in the dark.

According to the inventive method it is also possible to leave out any anthocyanin coloration in any desirable shape on the plants and/or fruit, by covering the non-pigmenting, or little pigmenting plants and/or fruit with an opaque cover in such a shape before the irradiation process, and then removing this cover after completion of the irradiation.

According to the inventive method, this results in the possibility to substantially improve a generally known method for applying drawings and writing onto the surface of fruit, in particular apples, because the new method can also be applied to fruit varieties that otherwise stay green. Another benefit is the fact that this variation of the method can also be applied long after the harvest, whereby an irradiation period of only 2 days may suffice in order to cause a clearly visible anthocyanin production.

The fruit surface therefore becomes a new marketing surface, for instance. Christmas motives, company logos, first names, as well as all sorts of sayings can be applied to the surface of the fruit in such a way. This enriches fruit sales by an additional possibility. Due to the fact that the pattern can be applied very rapidly, and independent of the fruit type, the invention, with its rapid and simple method of subsequent red coloration of fruit, in particular of apples, offers a decisive benefit over the known methods. The inventive irradiation method enables the application of a motive onto the surface of the fruit even late after the harvest and by short-notice orders.

According to the inventive method the anthocyanin production, especially with the use of UVB light, or a mixture of UVB and white light, can be accelerated as opposed to common methods.

A decisive benefit of the inventive method in the irradiation of plants and/or fruit is that it can be performed rapidly, and without extensive technical effort, and can be easily incorporated into existing procedural steps from planting to the sale. It is especially beneficial in fruit, in particular in apples, as the method can be integrated in established storage steps. Fruit, in particular apples, can be irradiated without loss of freshness, and

then be stored as usual under ULO, or CA storage conditions. The most extensive step in the overall sequence, namely the lighting, can then be centralized, i.e. integrated into the storage operation.

Surprisingly, it was further discovered, that such fruit in particular, which remains green during normal ripening and storage, such as green apples, show an intense red coloration after treatment with UVB light, or a mixture of UVB and white light.

**Figures:**

Figure 1 is a schematic drawing of an irradiation chamber suitable for the inventive method.

Figure 2 contains 2 photographs of apples (a: Zitronenapfel, b: Golden Delicious), which were photographed after a 7-day irradiation with 4 different light types (UVA/white, UVB, blue/white, UVB/white).

Figure 3 is a bar chart showing the absorption of extracts at 527.5 nm from the skin of Pilot Apples versus the irradiation time in hrs for 2 tests (anthocyanin measurement directly after irradiation; anthocyanin measurement after irradiation and additional 7-day storage).

**Examples:**

METHODOLOGY:

A climate chamber (1) adjusted to 17°C as illustrated in figure 1 is used for the inventive irradiation method. Working with multi-color, or UV light, respectively, 2 lamps (2) each (distance of 50 cm, each 25 cm from the center of the ceiling) were attached to the ceiling of a climate chamber with the following dimensions: 160 cm high x 120 cm wide x 140 cm deep, at a height of 80 cm. With the use of mixtures of multi-color, or UV light with

white light, two additional white lamps ([illegible]) were used, which were attached to the right and to the left side of the multi-color (or UV) lamps (2), each 10 cm further apart from the ceiling center. For irradiation using white light, 4 lamps (2, 3) were used, which were arranged the same way as with the mixed light irradiation. The position of the fruit to be irradiated (20 – 50 pieces of fruit per test) is illustrated by black bars (4). The distance between the fruit and the lamps is indicated by a double arrow (5). The interior walls of the entire chamber (1) were lined with metallic foil serving as a mirror.

The chamber was separated by a black separating wall (6) not lined with mirrors whenever a test construction "half chamber" is mentioned in the examples. The tests involving a "half chamber" therefore only used 1, or 2 fluorescent lamps, and approximately half of the light intensity.

The irradiations were performed using the following light sources.

White light: Phillips TLD 36W/83 (length: 120 cm)
Blue light: Phillips TLD 36W/18 BLUE (length: 120 cm)
Red light: Phillips TLD 36W/15 RED (length: 120 cm)
UVA: Phillips TL 60W/09 N" (length: 120 cm)
UVB: Phillips TL 40W/12 (length: 120 cm)

The irradiation flow distribution stated in chart 1 was calculated for the lamps (distance approximately 65 cm, one lamp each).

The anthocyanin production involving the increase of red coloration of the test fruit was evaluated according to the three following methods.

1. Determination of the chromameter values (Y, x, y), whereby Y stands for brightness, x stands for blue-yellow values, and y stands for red-green values of the color. Each color can therefore be "re-composed" from these three numerical values. The contained values are reproducible at a high degree. The measurements were taken using a device

known as "Chromameter II Reflectance" manufactured by Minolta. The test fruit was measured as follows:

The probe was read three times, and median values were indicated for each test point. The variations are $\leq 3\%$ from the median. The value variation therefore lies in the inevitably imperfect symmetry of the fruit.

2. Photometric absorption measurements at 527.5 nm: after peeling the fruit, three circular areas totaling 2.4 $cm^2$ were punched out of the peel of the fruit with a cork drill, which were extracted once by shaking them in 1.5 ml of a mixture of 10N-HCl and methanol at a volume ratio of 1:99 (1% 10N-HCl = 99% MeOH). Then the absorption of the extract was measured at 527.5 nm in a vessel with a path length of 1 cm using a commercially available photometer manufactured by Perkin-Elmer.

3. Optical evaluation: Before laying out the fruit, black adhesive labels under which the original color was preserved during irradiation, were applied to the skin. After completion of the light treatment, a photograph was taken, and the original color was compared to the directly adjacent newly created color. Figures 2a – 2b contain the photographs showing several of the tests performed. The fruit was classified as follows in the optical evaluation:
"+++": very strong red coloration
"++": strong red coloration
"+": weak red coloration
"-/+": very weak red coloration
"-": no red coloration

All three methods supplied completely identical results.

EXAMPLE 1 (kinetics)

Freshly harvested apples (harvest in the fall of 1997 and 1998) of the following varieties were supplied from the test stock of the University of Hannover. Irradiation of the

following varieties was performed at "half chamber," 0 to 5 days each after the harvest (exception: Mutsu was tested in the "full chamber").

Red varieties: *Cox Orange, Elstar, Gloster, Idared, Jonagold, Pilot*;
Green varieties: *Golden Delicious, Zitronenapfel, Mutsu*

Additionally, in example 1, the red coloration of *Granny Smith* apples from New Zealand, which had already been in storage for 30 – 50 weeks, was tested in a trial using a "full chamber."

Apples of equal coloration were selected from each type. One apple each was then irradiated over a time period of 0, 3, 5, or 7 days inside the climate chamber (17°C) as described above using permanent light. The following light sources were used

- a mixture of blue light and white light (invention)
- blue light (comparison)
- UVB light (invention)
- a mixture of UVB and white light (invention)
- UVA (comparison)
- a mixture of UVA and white light (comparison).

The light sources were arranged as described in paragraph "Methodology."

Immediately after the irradiation each apple was measured with a chromameter. Then a piece of the apple peel was removed with a cork drill, which was then analyzed as to its relative contents (based on the zero values) of anthocyanin in the method (2) described above.

The values for "0 days" (zero value) was obtained by evaluation of the surface containing the label, or by measurement at the beginning of the trial.

The results are compiled in table 2a. The variations of the measured values are due to the never perfect concordance between the apples and a measuring sequence. Part of the

[illegible] results is illustrated in figures 2a – 2b. The green apple varieties include (2a: Zitronenapfel, 2b: Golden Delicious), which were each irradiated for 7 days using the following light types:
1: UVA/white, 2: UVB, 3: blue/white, 4: UVB/white

The results of additional trials under identical conditions, but in which only a photometric anthocyanin measurement took place after 0 and 3 days, is illustrated in table 2b.

The increase of red anthocyanin after irradiation with UVB or UVB/white light are identified in figures 2a and 2b by the circular surface on the apples, which corresponds to the area covered by an opaque foil, under which the color of the non-irradiated apples was preserved.

The results show that the production of red anthocyanin was greatly promoted by UVB light, whereby the effect can be increased by mixing it with white light. Good results were also achieved in varieties naturally turning red using a mixture of white and blue light. The effects resulting from a mixture of white and blue light, however, were weaker than the irradiation using UVB light or the irradiation using a mixture of UVB and white light, with a few exceptions, so that a noticeable coloration could only be observed after an irradiation period of more than 7 days. Blue light alone results in a much weaker effect, than UVB, or UVB/white. The irradiation using red light and UVA (with or without white light) was nearly without any effect. Since UVA and UVB tubes in their visible ranges show approximately the same, although lower irradiation density (see table 1), this result proves that the results achieved with UVB were not caused by "contamination" with white or blue light.

Tables 2a and 2b (Mutsu, Zitronenapfel, and Granny Smith) also show that a anthocyanin production in "green" varieties can only be achieved by UVB light, in particular with a

mixture of UVB and white light.

EXAMPLE 2 (irradiation and subsequent storage)

The apple varieties *Cox Orange, Jonagold, Pilot, and Golden Delicious* were irradiated in example 1 under the stated conditions at 0 hrs, 12 hrs, 24 hrs, and 40 hrs, using a mixture of UVB light and white light in the climate chamber (17°C). The measurement of the anthocyanin production in example 2 took place not only directly after irradiation, but also after an additional 7-day subsequent storage in a refrigerator (at 4°C). The measurement of the anthocyanin production took place using the previously described methods (1) and (2). The results are summarized in table 3. The results achieved with the Pilot apples (and additional measurements of Pilot apples after 28 hrs, 36 hrs, 48 hrs, 52 hrs, and 60 hrs) are graphically illustrated in figure 3. Figure 3 is a bar chart, which illustrated the anthocyanin production (measured by absorption measurements at 527.5 nm) for Pilot apples, which were measured either immediately after irradiation, or after additional subsequent storage of one week at 4°C in the dark. The slight variations observed are due to the fact that the measuring sequence had to be performed using different apples.

The results show that 12 hrs are sufficient in an irradiation using a mixture of UVB light and white light in order to induce a noticeable anthocyanin production.

The comparison to the respective values of example 1 further shows that anthocyanin continued to form during a subsequent storage in the dark (4°C). Very good values can be achieved after only 24 hrs of irradiation, and 7 days of subsequent storage.

EXAMPLE 3 (stored apples):

Freshly harvested apples of the following varieties were stored up to 3 months at normal conditions, or up to 12 months at ULO conditions, and then irradiated under the same

conditions as in example 1, with the exception that they were irradiated for a period of 3 days, or 7 days, respectively (in some cases 13 days), whereby the following measurements were performed depending on the light source(s) used:
7-day values (13-day values) for blue/blue + white/UVA, 3-day values for UVB and UVB + white.
The anthocyanin production was determined according to methods (1) through (3).

Red varieties: *Cox Orange, Elstar, Gloster, Idared, Jonagold, Pilot;*
Green varieties: *Golden Delicious, Granny Smith,* and *Mutsu.*

The (not illustrated) results showed that even with the irradiation of apples having been stored for a longer period of time using a mixture of UVB and white light, the red coloration was fully formed after three days in all apples.

The mixture of blue + white light showed a stronger effect, than with freshly harvested apples. As opposed to freshly harvested apples (compare table 2) a noticeable red coloration can be achieved after only 7 days. A bright red coloration, based on green apple varieties, could be achieved, for example, after 13 days of irradiation with a mixture of blue and white light on stored Idared apples.

UVB by itself has a highly accelerating effect on varieties that do not easily turn red (such as Cox Orange), as well as with all other varieties. In varieties that turn red easily, such as Pilot and Gloster, blue light (or a mixture of blue and white) already have an accelerating effect.

The time frame of the red coloration in easily red-turning varieties is not substantially faster, than in the green varieties.

However, the most surprising [illegible] was that the [illegible] of the green varieties with UVB alone [illegible] event stronger, also with UVB + white completely [illegible].

EXAMPLE 4 (other fruit):

Stored, still green pears of the variety Abate (country of origin: Italy) were irradiated in the same way as in example 1, however only with UVB light, UVB and white light, blue light, and blue and white light. Only the UVB, or UVB and white light, respectively, resulted in a red coloration of the fruit after 3 to 7 days.

This result shows that the inventive method can also be applied to fruit other than apples.

Table 1

Irradiation Flow Distribution

[see source for table]

| | | | |
|---|---|---|---|
| White | | blue | red |
| Blue | | | |
| Red | | | |

Table 2a

[See source for table]

| Light source | chromameter values | absorption | optional evaluation |
|---|---|---|---|
| Blue | | | |
| Blue + white | | | |
| UVA | | | |
| UVA + white | | | |
| UVB | | | |
| UVB + white | | | |

Table 2a (continued)

[See source for table]

Table 2a (continued)

[See source for table]

[Footnotes:]

(a) compare fig. 2a
(b) compare fig. 2b
(c) if box is blank, no measurement was performed

Table 2b

[See source for table]

Light source absorption

Blue

Blue + white

UVA

UVA + white

UVB

UVB + white

Table 3

[See source for table]

Irradiation period
With UVB/white light chromameter values absorption

[Footnotes:]
B = Irradiation L = Storage